NATIONAL REPORT OF INDONESIA

Contributions to the Global Sea Level Observing System

BAKOSURTANAL

National Coordinating Agency for Surveys and Mapping of Indonesia

11 - 15 May 2009, Paris, France

Eleventh Session of the GLOSS Group of Experts
GLOSS GE XI and associated Workshop

NATIONAL REPORT OF INDONESIA

Dr. Parluhutan Manurung
National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL),
Jl. Raya Jakarta-Bogor Km 46 Cibinong INDONESIA.
Email: parluhutan@bakosurtanal.go.id

1. Introduction

The demand for high rate sea level data transmission enabling a tsunami warning issuance in both Indian Ocean and the Indonesian Internal Sea Waters has been increasing after the tragedy of the 2004 Sumatra Tsunami. As it is known, the tsunami was the most catastrophic in recorded history, causing great loss of lives with more than 120,000 fatalities in Indonesia and thousands more over 9 countries in Asia. If an early warning system were available in the region, many lives could have been saved.

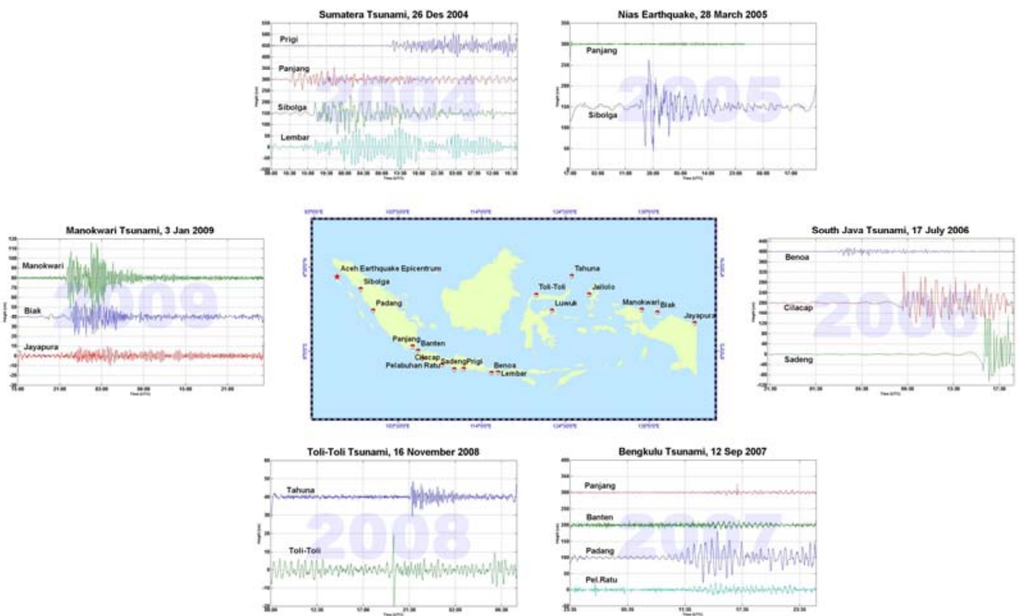

Figure 1. Tsunami occurrences at least once in a year since 2004

Realising the great loss in the tragedy and in support of the early warning system in both Indian Ocean and internal waters of Indonesia, Indonesia has allocated national funding for establishing the Indonesian Tsunami Early Warning System (IdnTEWS). This can be claimed as a turning point in the development of real time coastal sea level monitoring network in Indonesia. Unexpectedly, the tsunami events occurred at least once in a year starting from the devastating tsunami to date and these have been triggering the efforts to speed up the progress development of the warning system in the region. More important, the distribution of earthquakes generating tsunamis, as can be seen in Figure 1, shows that the threat is not only found along the coastlines facing the Indian Ocean, but also in both the Internal Waters and Indonesia that facing Pacific Ocean. Therefore the needs to distribute more stations to the Eastern parts of Indonesia should be carried out and this of course requires more investment.

This paper reports the station distribution of the existing network, a description on technology applied, GPS technology added in the network, and data availability.

2. Station Map Distribution

The Permanent Sea Level Monitoring Network of Indonesia is fully centralised under the responsibility of BAKOSURTANAL in terms of budgeting, maintenance and data processing. However, the contribution of the local port authorities is considerable by assigning at least one of their staff to operate the station on a daily basis. The network is aimed at functioning as reference stations serving for multi purpose as such as from practical application to research. The network distribution is still far than adequate for representing tidal characteristics along the entire country coast line. Assuming that one tidal station represents a tidal regime of about 100 km of coast line length, an ideal number of permanent tidal stations, classified as reference stations, for the whole country should be about 810 stations. Therefore, the network is still gradually expanding in number of stations with support not only from the tsunami warning program, but also from support of inter department for densification of the network until it possibly reach the idealistic station distribution.

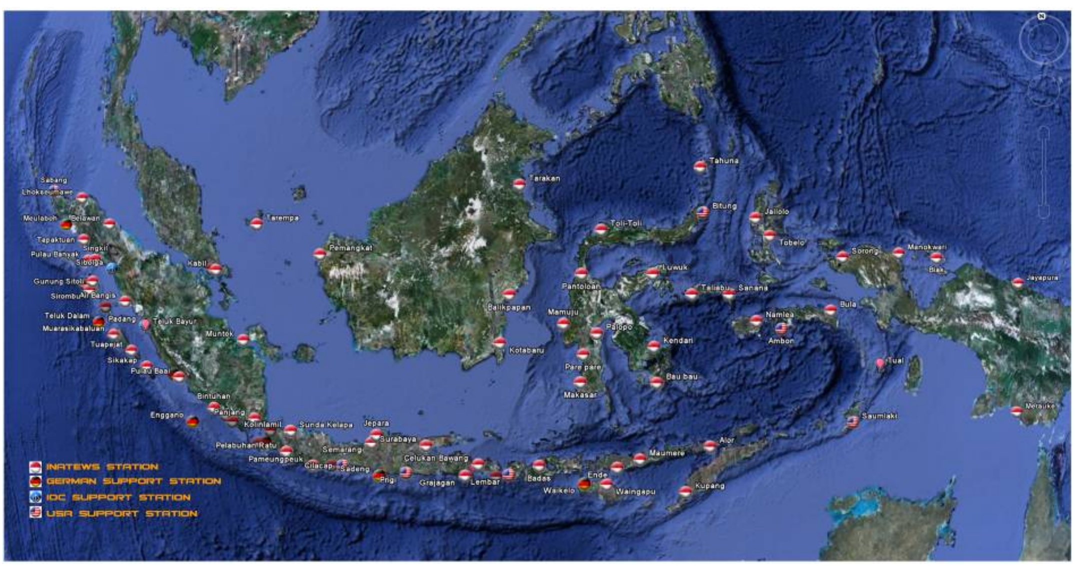

Figure 2. Distribution map of the Indonesian Sea Level Monitoring Network

Support for development of the sea level component of InaTEWS is derived from mainly four sources of funding available at present that have contributed to the upgrade and installation of tide gauge stations. The support and number of the installed of agreed stations are as follows:

- The German - Indonesia TEWS (GITEWS) Programme has installed 7 out of 10 agreed sea level stations and the remaining will be completed by the end of 2009. Each station consists of continuous GPS monitoring, a ground meteorological sensor and multiple communication capabilities such as GTS, BGAN/Inmarsat, and PASTI.
- USA Government under NOAA/University of Hawaii Sea Level Centre (UHSLC) joint collaboration and with financial assistance from USAID, has partnered with BAKOSURTANAL to install 7 out of 10 agreed stations using GTS. The capability of stations will be upgraded gradually to use BGAN communication and continuous GPS monitoring planed to take place by May 2009.
- The IOC has provided funding for 3 tide gauge station upgrades. UHSLC and BAKOSURTANAL partnered to install all the agreed stations. The work completed by the early of 2008. The capability of stations will also be upgraded gradually to use the BGAN communication and continuous GPS monitoring expected to start by May 2009.
- Indonesian government under the InaTEWS Programme supports funding has completed to install 40 out of 60 agreed stations using GSM and VSAT platforms. However, the completion of the remaining stations is still subject to funding availability.

The progress of new developments of Indonesia Coastal Seal Level Monitoring Network has been achieving in total 90 stations with the following summary, namely:

- **First Order Sea Level Network** consisting of 57 out 80 planned real time stations supporting both IOTWS and InaTEWS. This is designed to use multiple-use platforms and various communication tools for back up as such as GTS, BGAN, PASTI (Indonesian Satellite-based Communication provider), VSAT and GSM data.
- **Second Order Sea Level Network** consisting of 25 float gauge digital stations using GSM data connections. This order is mainly distributed in the internal water of Indonesia which is relatively not prone to tsunami threats.
- **Third Order Sea Level Network** consisting of 8 operational analogue (graphical chart) stations. Since the cost for operational is higher than that of digital, this type will be gradually replaced with digital in the next few years.

Efforts to adopt local arts and culture impression on the outlook of the tidal huts have been made allowing participations from the local people to keep the stations from destructions and vandalism, as shown in Figure 3(a). The UNESCO Jakarta under JTIC programme has generously provided a poster explaining to public living in tsunami at risk about the importance of sea level stations in supporting tsunami warnings, as shown in Figure 3(b).

(a)

(b)

Figure 3 Adopting local art and culture in the tidal hut outlook **(a).** Poster for explaining to public about the importance of sea level stations in supporting tsunami warnings **(b)**

3. Tide Gauge Technology

The stations supporting tsunami warnings consist of multiple-use platforms using higher data sampling rate which provide the range, durability and sampling capability to monitor tsunami signals including stability and accuracy to measure long term sea level trend and its variations. The stations dedicated to non-hazard monitoring are adequately equipped with single type of sensor with float gauge or pressure.

The sensor basic configuration for natural hazard monitoring capability should use combination of the three different types of sensors consisting of pressure, float gauge and radar. The three types of sensors should be capable of operating independently and have a 0.5 millimetre height resolution over a range of 0 to 15 meters. This will ensure to provide back-up and redundancy, continuous observations during extreme water levels and long term satisfactory performance for at least 12 months. The common specification of three types level sensors are as follows:

- **Radar gauge tidal recording** with 10 second data sampling rate enabling monitoring of sea level with high time resolution recording. This should be a primary sensor in supporting the warning system by having the advantage of ease of operation and maintenance since a direct contact to the sea water is at the very minimum level and the stilling well is no longer necessary
- **Pressure gauge digital recording** with one minute data sampling rate and high capability in detecting quick changes of water pressure caused by tsunami and this is also adequate to fill any short gaps which may occur in the radar type. The installations of this type have been showing more widespread use including in the future plan of network densification in particular for practical applications.
- **Float gauge digital recording** with one minute data sampling rate, allowing real time monitoring that can cover extreme sea level changes for relatively short time durations. In some current areas it is found not possible to install a well in the installations request a considerable amount of costly engineering work.

Both of the GITEWS and Indonesia support stations are equipped with sensors manufactured by the same company while those supported by NOAA/UHLSC use those of different manufacturers and then customised them in one system using data loggers supporting the GTS transmission. It is found that some problems related to firm ware could not be fixed on site and this should only be handled by manufacturer for commercial reasons. Therefore, number of spare units of data loggers and sensors should be available allowing to a quick recovery and subsequently this will keep an optimal data recording.

Communication is one of the main bottlenecks in the development of an early warning system in terms of maintenance and airtime cost. The operational demands driving the data communications system requirements are: i) Reliable real time data streaming (every minute), ii) system stability, iii) system versatility and two-way communication capability, iv) ability to expand usage, and iv) affordable cost. The demands would only be fulfilled by using different communication channels such as VSAT, GTS/Meteosat, BGAN, and GSM data, which are all running independently, if possible. This provides a more robust system to ensure that the system is able to receive data during emergencies. The use of satellite based data communication with solar cell for a self-supporting power supply should be the most reliable option for the vast archipelagic region.

In a normal situation when the required data transmission rate is not that high, use of Meteosat or Japanese geostationary satellites and GTS provides the most reliable option for data transmission. This approach allows for data transmissions every 15 minutes, the satellite link modem consumes low energy, and the transmission air time is free access due to the generous support of WMO. However, Indonesia is located in the potential tsunami risk front lines where the time needed for tsunami waves to reach the nearest coastline is 15 minutes on average. This communications option is not meant for facilitating an extreme mode with faster data transmission requirements, such as one minute transmission rates when a tsunami occurs. This high transmission rate often requires that the system trigger the stations, located close to the tsunami source, to continuously transmit data in the event of a major earthquake. This allows the experts on duty at the Indonesia Tsunami Early Warning Centre to make a decision to evacuate or not to evacuate.

Problem of providing a sufficient power supply is mostly encountered in high rate data transmission using satellite unlike that of using GSM/GPRS of which range of distance for transmission is shorter compare to the former. A worse condition will occur when orientation of the antenna is not correctly pointing to the assigned satellite. Several types of satellite communication used namely GTS; Inmarsat/BGAN, Iridium and Indonesia Satellite PASTI. The 15 minute interval data transmission with GTS is found relatively very stable and reliable as indicated mostly over 90% data record availability. The one minute data transmission interval capability with BGAN is added later in the system fulfilling a higher rate transmission for coastal zone of Indonesia classified tsunami at risk. It is found that the performance is reliable though modems of some stations should need to be repaired. In fact, the transmission is not set to a constant one minute transmission rate but it is set to capability of one minute transmission which is triggered during a tsunami mode.

The use of VSAT in the Indonesian support stations is the high priority option since this is the best solution at present for real time data communication. It is becoming more cost effective and reliable for a vast area such as Indonesia with an archipelagic condition where mostly very minimal terrestrial communication infrastructure is available. The VSAT instrumentation should have a high standard technical specification, such as all connectors should be hermetically sealed to protect the electronics from water, dust and particularly high salinity in outdoor and marine environments. Problem of power supply is still unavoidable due to the consumption of power is higher compare with other communication platforms.

In the year 2009, it has been initiated to use the Iridium communication as it has been used by the Agency for the Assessment and Application of Technology (BPPT) in the development of Indonesia support buoys.

The use of the terrestrial based transmission using a wireless communication should be a better option since the area coverage of GSM/GPRS facilitated by numbers of providers is significantly improving in the country. Although it is susceptible to a local earthquake but it is found that providers show more reliable capacity for a quick recovery. Again, the density of station distribution could compensate failure of the neighbouring stations allowing monitoring the propagation of tsunami in the region at risk. As some GSM/GPRS providers are now facilitating a monthly based subscription with a more affordable cost, BAKOSURTANAL has initiated to start a real time transmission at some stations and this will be expanded covering the whole network if the signal coverage is available.

The stations mostly rely on batteries charged by solar panels for power since local power is not an appropriate option at many remote areas and more importantly that local power is vulnerable to failure in the event of earthquake or tsunami run off. However, despite that high intensity of sun shine but both high humidity and cloud are factors greatly reducing an optimal capacity of solar power in the equatorial region. Considering the factors, several batteries, mostly those of maintenance free, should be available more than required for back up enabling to maintain power in a worse condition where sun shine availability resulting from high rainfall and cloud is not sufficient to recharge the batteries for at least four days.

Optimal sea level observations still require local operators to routinely check and maintain the station. BAKOSURTANAL assigns in total 120 local operators, recruited from the local port authority office where the stations are located. The operators play a very significant role in maintaining the stations to ensure the full operation of the instruments. This is because the recording instruments used in the network still require a regular maintenance and more important, the stations are mostly located in busy ports which are prone to damage by traffic in the harbour and vandalism. A minimum weekly monitoring contact carried out by a staff on duty in BAKOSURTANAL office to the operators. It is now possible since most of the operators could afford to have mobile phones unlike in the past when contact with operators were difficult since contact can only be done with fixed line and some with letters. Training workshops for improving the operator's skill on station maintenance have been conducted regularly. The results of the regular monitoring and training have been encouraging, as indicated by a significant improvement in data quality and data return from an average of 60 to 95%.

4. GPS Technology

The first initiative to incorporate continuous GPS measurements in the sea level monitoring system in Indonesia carried out under the GITEWS programme. This is a significant improvement for both determination of geocentric position of the stations and separation of thermal expansion from the sea level variation records. Considering the locations of the coastal stations are mostly in harbour with geological formation of alluvial sediments, the variations are partly caused by ground layer compaction and subsidence. The high accuracy of height derived GPS time series is also significant to show indication of instability occurred with the jetty piers of which this could also affect the sea level records.

Stations supported under the GITEWS program are all equipped with geodetic type GPS receivers together with ground meteorological sensors enabling for the computation of more high accurate atmospheric corrections required for the determination of precise height component. The additional sensor is also useful for other applications as such as GPS meteorology. In term of tsunami warnings, the station with atmospheric measurement capabilities is also of great importance to ensure that the extreme sea level change indicated during the tsunami alert mode is not caused by a positive surge and vice versa.

Figure 4. The tidal huts with GPS antenna on top located in Seblat (Sumatra) and Sadeng (Java).

More importantly, the coastal gauge GPS stations are also of importance to provide formation of baselines used for ambiguity resolutions to the nearest GPS buoys located offshore. The data is transmitted hourly using Inmarsat/BGAN to BAKOSURTANAL and German Research Centre for Geosciences (GFZ) servers and the system has a capacity to trigger the transmission in higher rate during the tsunami mode. Figure 4 shows the tidal hut located in Sadeng (Western tip of Java) and Seblat (Western coast of Sumatra) with the GPS antennas at the roof top.

Another initiative will be carried out at several of the ten existing coastal sea level stations supported by both NOAA/UHSLC and UNESCO. The installation is planned to start by early May 2009. Table 1 shows the existing and planned continuous GPS observations at the sea level monitoring stations supported under GITEWS, IOC, and NOAA/UHSLC. In total there will be at least 20 continuous GPS capable sea level stations in the Sea Level Monitoring Network of Indonesia.

Table 1. The existing and planned continuous GPS observations at the sea level monitoring stations. The sea level data is free accessible from the UNESCO/IOC website.

No	Tide_Station	LAT	LONG	GPS Availability	Data Communicaton
1	Ambon	-3.683	128.183	Planned	GTS
2	Benoa	-8.767	115.217	Planned	GTS
3	Bitung	1.450	125.200	Planned	GTS
4	Cilacap	-7.750	109.000	Planned	GTS
5	Enggano	-5.346	102.271	Yes	GTS & BGAN
6	Lembar	-8.733	116.083	Planned	GTS
7	Meulaboh	4.127	96.130	Yes	GTS & BGAN
8	Padang	-0.950	100.367	Planned	GTS
9	Prigi	-8.283	111.733	Planned	GTS
10	Sabang	5.833	95.333	Planned	GTS
11	Sadeng	-8.300	110.567	Yes	GTS & BGAN
12	Saumlaki	-7.984	131.291	Planned	GTS
13	Seblat	-3.222	101.602	Yes	GTS & BGAN
14	Sibolga	1.750	98.767	Planned	GTS
15	Tanjung Lesung	-6.478	105.658	Yes	GTS & BGAN
16	Teluk Dalam	-0.553	97.822	Yes	GTS & BGAN
17	Waikelo	-9.390	119.219	Yes	GTS & BGAN

5. Data Availability

The percentage of data record per year is improving greatly after the era of digital sensors together with reliable communication tools enabling remote monitoring of the sensor performances. The availability of mobile phone owned by most operators nowadays also enables to facilitate troubleshooting and quick recovery by the local operators via a remote help by the engineer on duty at the BAKOSURTANAL office. This is hardly possible to carry out in the past. This significant progress is indicated by the list of higher percentage data record as shown in Appendix 1.

In supporting the tsunami warnings, the real time sea level data from the BAKOSURTANAL Sea Level Centre's computer server should flow continuously to that of the National Tsunami Warning Centre (NTWC) via a dedicated internet connection. The data streaming is displayed on web-based and this be incorporated to the Decision Support System (DSS) in NTWC by the end of year 2009. The flow of the sea level data can be seen in Figure 5 and the web-based display of the real time sea level transmitted to the Warning Centre is shown in Figure 6.

Indonesia with supports of the partners has also been contributing a free access real time data from 17 stations with the list of station as shown in Table 1. The data is displayed in the UNESCO/IOC website with the address as http://www.ioc-sealevelmonitoring.org/. The data is made available in accordance with the IOC Oceanographic Data Exchange Policy as adopted by the 22nd session of IOC Assembly in Resolution 6.

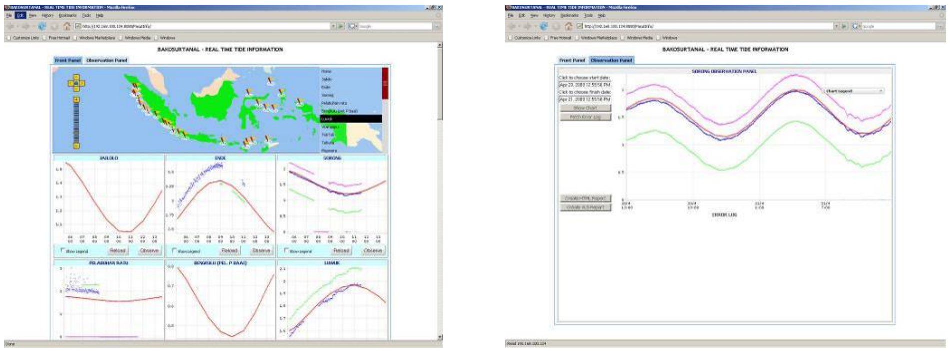

Figure 5. Real time sea level data flow from the Indonesia sea level centre (BAKOSURTANAL) to the Tsunami Warning Centre (BMKG) transmitted through a dedicated line.

6. Conclusion

The development of the Indonesian Real Time Coastal Sea Level Network is progressing significantly in support for both InaTEWS and IOTWS. There are 57 of 80 planned stations already in place and the total number of stations in the network consists of 90, as of May 2009. Ongoing attempts to complete the deployment of the remaining stations and the data display including a quality control capability which have been pursued.

The extensive network uses different communication channels such as VSAT, Meteosat/GTS, BGAN, PASTI and GSM data, which are all running independently, if possible. As Indonesia coastlines are close to tsunamigenic areas, the communication system should be capable of operating in an extreme tsunami mode where data transmission fast rate from the stations is required. The significant addition of new real time sea level stations is a great opportunity to improve an operational ocean observing system covering the whole Indonesia region with a better distribution.

The deployment of GPS receivers and meteorological sensors at sea level stations will greatly contributing to both the high precision vertical control supporting tsunami and climate research.

7. Acknowledgements

The author would like to thank Mr. Rudolf W Matindas, the Chairman of BAKOSURTANAL for his encouragement to report the Indonesian activities on monitoring sea level to related international bodies. Especially, the author would like to thank the support from Ms Henny Liliwaty, Deputy Chairman of

Spatial Data Infrastructure, Mr. Rustandi Poerawiardi, Head of Centre for Geodesy and Geodynamics and the author's colleagues in Gravity and Tide Division, namely Irpan Septiawan, Erfan Dany Variandy, Joko Ananto, Sri Handayani, Sofie Barlianto, Supriadi, Ruddy Sorongan, Amir Machmud, Bayu Triyogo and Tunjung Wismadi. Without their help, the writing of this paper would not have been possible.

8. References

Intergovernmental Oceanographic Commission, 1985. Manual on sea-level measurement and interpretation. Volume 1 - Basic procedures. Intergovernmental Oceanographic Commission Manuals and Guides No. 14. IOC, Paris, 83pp.

Manurung, P. et al, 2009. Tide Prediction Book 2009. BAKOSURTANAL, Cibinong Indonesia.

Manurung, P. et al, 2008. Progress Development of the Indian Real Time Coastal Sea Level Network Supporting Tsunami Early Warning System. International Conference of Tsunami Warning, Bali, Indonesia.

Merrifield, M.A. et al., 2005. Tide gage observations of the Indian Ocean tsunami, December 26, 2004, Geophys. Res. Lett. 32, L09603, doi:10.1029/2005GL022610.

Pugh, David T., 1987. Tides, Surges and Mean Sea-Level. John Wiley & Sons, Singapore.

Rabinovich, A.B., Thomson, R.E., 2007. The 26 December 2004 Sumatra Tsunami: Analysis of Tide Gauge Data from the World Ocean Part 1. Indian Ocean and South Africa. Pure Appl. Geophys. 164 (2007) 261–308.

The State Ministry of Research and Technology, 2006. Grand Design of Indonesia Tsunami Early Warning System. The Republic Indonesia State Ministry of Research and Technology Office, Jakarta.

BAKOSURTANAL Sea Level Monitoring Centre
Jl. Raya Jakarta-Bogor Km 46 Cibinong INDONESIA

APPENDIX 1: List of Stations, the Availability of GPS Stations and Percentage of Data Record Since 1984 to 2008.

No	Tide_Station	LAT	LONG	GPS Availability	Data Available Since (percentage)																								
					1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	Air Bangis	0.197	99.377	-																									42
2	Alor	-8.360	124.690	-																									100
3	Ambon	-3.683	128.183	-										67	92	92	92	100	75	42	0	0	0	33	17	100	100	92	92
4	Badas	-8.467	117.383	-																						100	100	92	83
5	Balikpapan	-1.283	116.800	-										100	100	100	100	100	67	100	50	33	8	67	8	50	83	75	100
6	Banten	-6.019	105.951	-																				58		75			100
7	Bau bau	-5.467	122.583	-																									58
8	Belawan	3.767	98.700	-																						100	100	100	100
9	Benoa	-8.767	115.217	-				42	100	100	92	50	100	100	92	67	100	92	100	92	33	50	100	100	67	100	100	100	75
10	Biak	-1.167	136.050	-								75	83	67	75	100	75	50	42	75	100	58	0	67	50	50	33	58	100
11	Bintuhan	-4.840	103.410	-																									100
12	Binuangeun	-6.500	105.320	-																									83
13	Bitung	1.450	125.200	-				92	92	92	67	83	100	33	92	100	100	17	92	92	75	58	17	67	50	67	58	8	58
14	Bula	-3.100	130.505	-																									0
15	Celukan Bawang	-8.183	114.833	-																						58	75	92	100
16	Cilacap	-7.750	109.000	-	83	100	0	42	75	75	67	92	100	100	100	92	100	25	33	75	25	92	50	100	83	100	100	67	83
17	Ende	-8.860	120.650	-											92	100	42	0	8	0	0	58	25	0	42	0	42	0	75
18	Enggano	-5.346	102.271	√																									75
19	Grajagan	-8.610	114.226	-																									50
20	Gunung Sitoli	1.310	97.610	-																									92
21	Jailolo	1.060	127.470	-										67	100	17	17	17	83	33	92	92	0	100	100	100	100	92	58
22	Jayapura	-2.550	140.717	-												17	0	58	25	17	0	0	58	100	67	100	100	100	100
23	Jembrana	-8.386	114.575	-																									58
24	Jepara	-6.583	110.650	-										92	100	100	100	92	100	92	100	58	100	100	92	100	100	75	100
25	Kabil	1.067	104.133	-													100	100	100	33	0	25	33	58	8	67	0		58
26	Kalianget	-7.050	113.967	-																									75
27	Kendari	-3.967	122.583	-																						0	75		67
28	Kolinlamil	-6.107	106.891	-																									92
29	Kota Agung	-5.500	104.617	-																									25
30	Kota Jawa	-5.500	104.213	-																									92
31	Kotabaru	-3.236	116.225	-																						75	50	25	75
32	Krui	-5.190	103.930	-																									75
33	Kupang	-10.200	123.517	-							0	83	92	100	100	100	100	100	100	83	42	25	50	100	83	100	83	100	8
34	Lahewa	1.230	97.120	-																									75
35	Lembar	-8.733	116.083	-									92	100	92	100	100	17	83	75	0	58	100	100	67	100	100	92	100
36	Lhokseumawe	5.217	97.100	-																									33
37	Luwuk	-0.950	122.810	-																									92
38	Makasar	-5.150	119.400	-						17	17	100	92	100	83	92	67	83	67	17	58	42	83	100	100	100	83		75
39	Malahayati	5.550	95.217	-						75	100	100	100	100	100	100	100	100	75	100	83								
40	Mamuju	-2.683	118.917	-						8	67	58	92	100	50	0	33	33	83	83	83	42	8	100	100	100	100	83	75
41	Manokwari	-0.850	134.083	-																									58
42	Maumere	-8.600	121.640	-																									100
43	Merauke	-8.467	140.383	-																							25	0	67
44	Meulaboh	4.127	96.130	√																									17
45	Muarasikabaluan	-1.200	98.600	-																									100
46	Muntok	-2.072	105.161	-													100	100	100	92	92	100	100	100	0	100	100	33	58
47	Namlea	-3.275	127.084	-																									0
48	Nusa Penida	-8.750	115.530	-																									100
49	Padang	-0.950	100.367	-				75	75	83	100	67	0	0	58	100	100	58	58	67	8	0	25	92	17	33	75	75	100
50	Palembang	2.850	104.900	-																				100		100	100	100	100
51	Palopo	-3.200	120.250	-						58	67	92	0	100	100	100	100	75	75	83	92	92	83	100	100	100	100	92	92
52	Pameungpeuk	-7.660	107.680	-																									92
53	Pangandaran	-7.710	108.500	-																									67
54	Panjang	-5.450	105.283	-					17	100	100	83	100	100	100	92	100	92	100	100	100	100	92	92	83	100	100		92
55	Pantoloan	-0.700	119.850	-																						67	100		100
56	Pare pare	-4.017	119.617	-																						100	100	17	67
57	Pelabuhan Ratu	-6.980	106.550	-																								67	75
58	Pemangkat	1.183	108.967	-											8	92	100	100	83	75	92	100	92	100	50	100	100	100	92
59	Pondok Dayung	-6.083	106.878	-	92	58	25	100	100	8	83	100	100	92	92	67	33	100	100	100	92	58	100	100	100	100	100	92	67
60	Prigi	-8.283	111.733	-										33	92	100	100	92	67	58	0	0	8	100	100	100	100	25	75
61	Pulau Baai	-3.380	101.860	-																				25		83	50	0	92
62	Pulau Banyak	2.290	97.410	-																									42
63	Pulau Tello	0.078	98.265	-																									100
64	Sabang	5.833	95.333	-																							100		67
65	Sadeng	-8.300	110.567	√															0	17	0	0	83	100	100	100	67		83
66	Sanana	-2.060	125.980	-																									42
67	Saumlaki	-7.984	131.291	-																						100	42	100	58
68	Seblat	-3.222	101.602	√																									67
69	Sekupang	1.133	103.917	-																									58
70	Semarang	-6.883	110.400	-		100	100	100	100	100	100	100	92	100	100	100		75	75	100	100	58	100	100	100	100	100	92	92
71	Sibolga	1.750	98.767	-						75	100	100	100	100	100	100	100	100	100	92	92	100	42	100	67	100	75	33	100
72	Sikakap	-2.767	100.217	-																									50
73	Singkil	2.285	97.820	-																									75
74	Sirombu	0.943	97.412	-																									33
75	Sorong	-0.860	131.290	-												42	75	100	100	75	100	92	25	100	25	100	92	33	67
76	Sunda Kelapa	-6.117	106.850	-																				100					100
77	Surabaya	-7.200	112.717	-	92	100	100	100	42	42	100	92	100	100	33	100	100	100	83	100	100	92	67	100	100	100	100	100	100
78	Tahuna	3.380	125.300	-																						100	75	75	100
79	Taliabu	-1.930	124.380	-																									83
80	Tanjung Lesung	-6.478	105.658	√																									83
81	Tapaktuan	3.267	97.183	-																									17
82	Tarakan	3.233	117.633	-												8	83	83	50	0	0	17	0	67	0	58	92	83	75
83	Tarempa	2.799	106.203	-																						100	100	17	67
84	Teluk Dalam	-0.553	97.822	√																									33
85	Tobelo	0.267	128.017	-																						33	33	42	67
86	Toli-Toli	1.050	120.830	-																									83
87	Tual	-5.633	132.733	-									92	100	100	100	100	75	17	0	0	0	0	42	75	100	100	33	0
88	Tuapejat	-2.000	99.500	-																									100
89	Waikelo	-9.390	119.219	√																									83
90	Waingapu	-9.530	120.150	-																							8		75

BAKOSURTANAL Sea Level Monitoring Centre
Jl. Raya Jakarta-Bogor Km 46 Cibinong INDONESIA